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THE EFFECTS OF FARM FIELD BORDERS ON OVERWINTERING SPARROW DENSITIES

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ABSTRACT.—Wintering birds that use farm fields may benefit from strips of uncultivated, grassy, and weedy vegetation, called field borders. Field borders were established on 4 farms in the North Carolina coastal plain in Wilson and Hyde counties in the spring of 1996. In February of 1997 and 1998, bird numbers on field edges and field interiors, with and without field borders, were surveyed using strip transect and line transect methods. Most (93%) birds detected in field edges were sparrows, including Song (*Melospiza melodia*), Swamp (*Melospiza georgiana*), Field (*Spizella pusilla*), Chipping (*Spizella passerina*), White-throated (*Zonotrichia albicollis*), and Savannah (*Passerculus sandwichensis*) sparrows and Dark-eyed Juncos (*Junco hyemalis*). We detected more sparrows on farms with field borders than on farms with mowed edges. This difference was most pronounced in field edges where field borders contained 34.5 sparrows/ha and mowed edges contained 12.9 sparrows/ha. Sparrow abundance did not differ by treatment in field interiors. Sparrow density in field borders was intermediate to wintering sparrow densities reported in other studies. These results suggest that establishing field border systems may be an effective way to increase densities of overwintering sparrows on farms in the southeastern U.S. coastal plain. *Received 8 March 1999, accepted 20 June 2000.*

Management of grain farms has changed dramatically in the past century. Economic pressures and advances in farm equipment have led farmers to make fields and farmed openings larger (Warner 1994), thereby reducing edge habitats. Advances in machinery, herbicides, and transgenic crops have enabled farmers to effectively control most non-crop vegetation in and around fields. These trends in agriculture have led to a dramatic alteration of the quantity and quality of wildlife habitat on farms and may have contributed to population declines of many farmland birds, including several species of sparrows (Warner 1994, LeGrand 1996).

The value of field edge habitat for farmland wildlife in general and emberizids in particular has been investigated in Britain and the Midwestern United States (O'Conner and Shrubb 1986, Best et al. 1995), but has not been extensively studied in the southeastern U.S. Many farmland sparrows, including Song (*Melospiza melodia*), Field (*Spizella pusilla*), and Savannah (*Passerculus sandwichensis*) sparrows rely on an interspersion of habitats in various seral stages (Bent 1968, Wheelwright and Rising 1993, Carey et al. 1994). Early successional habitats may be the most limiting habitat type on modern farms.

Sparrow populations may benefit from field borders, strips of uncultivated, grassy, and weedy vegetation along the edges of fields. The early successional habitat of field borders provides important breeding season nesting cover (Puckett et al. 1995, Marcus 1998) and also may be critical for overwintering sparrows by providing habitat for foraging, avoiding predators, and gaining protection from the elements. Food and cover have been implicated as resources potentially limiting winter densities of sparrows (Pulliam and Enders 1971, Davis 1973, Lima 1990, Watts 1990). Field borders potentially provide these resources and may increase usable habitat space on farmland for overwintering sparrows. The cost of managing to increase the amount of field border habitat may be minimal because net profits on field edges are less than in field interiors (Morris 1998) and several United States Department of Agriculture natural resource programs provide funds to subsidize farmers who leave field borders untilled. The objective of this study was to test the hypothesis that the presence of field borders increases the density of sparrows using farm fields, both in the edge and interior of fields.

STUDY SITES AND METHODS

Study sites.—Field work was conducted on two study sites in the North Carolina coastal plain, one in Wilson County and one in Hyde County. Each study

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site was divided into four farms. At each site field borders were established around each field on two farms, and two farms were left without field borders as controls. Throughout this paper "field borders" refer to the habitat enhancement strips in experimental fields, "mowed edges" refer to the corresponding area of mowed vegetation and crop residue on control fields, and "field edge" refers to the margin of a field with or without a field border. The farms contained similar crops (except where noted) and amount of woody edge and were located at least 1.7 km apart. Farms within each site were selected to be as similar as possible; however, some differences in management and surrounding landscapes existed.

The four Wilson County farms (77° 53′ W, 35° 42′ N), located in the upper coastal plain, averaged 250 ha ± 18 ha (SE) and contained irregularly shaped row-crop fields less than 2.5 ha each. Each farm contained 20–22 fields which comprised 43 ± 3% of each farm and were intermixed with a mosaic of house sites and timber stands of various ages. Field borders 5–10 m wide were established at field edges adjacent to drainage ditches, roadsides, and woodlines. Fields contained residue of corn (*Zea mays*), soybeans (*Glycine* sp.), and tobacco (*Nicotiana tabacum*).

The four farms in Hyde County (76° 05′ W, 35° 25′ N), located in the lower coastal plain, averaged 167 ± 18 ha and consisted of six to ten rectangular fields of 8–12 ha. The fields, arrayed in contiguous openings of over 200 ha, were separated only by drainage ditches or dirt roads. Farmed openings were bordered on one or two sides by a timber stand, and row-crop fields comprised 68 ± 1% of each farm. These farms were located on drained wetlands with organic soils and were typical of large ditch to ditch commercial agriculture of the lower coastal plain. Field borders 5–10 m wide were established along ditches located between fields. Fields contained residues of corn and soybeans. Field border farms were planted to winter wheat 5 cm tall at the time of the surveys in 1998.

Field borders were established at both sites in the spring 1996 by allowing vegetation to colonize the field edges. Field borders comprised 13.4% of tilled land in Wilson County and 9.8% of tilled land in Hyde County. Edges of control fields consisted of narrow (< 2 m) strips of annual vegetation that were mowed in early winter of each year.

Field borders in Wilson County consisted primarily of dead stalks of dog fennel (*Eupatorium capillifolium*), broomsedge (*Andropogon virginicus*), dormant blackberry (*Rubus argutus*), giant cane (*Arundinaria giganteum*), sapling sweetgum (*Liquidambar styraciflua*), and red maple (*Acer rubrum*). Field borders in Hyde County consisted primarily of dead stalks of dog fennel and fall panicum (*Panicum* sp.), dormant blackberry and giant cane, and sapling wax myrtle (*Myrica cerifera*).

Vegetation.—Vegetative structure of field edges was measured in February of 1997 and 1998 by visually estimating the percent cover and median height of standing vegetation. The percent cover was defined as the percentage of the 10 m strip that contained standing vegetation over 15 cm.

A detailed analysis of the composition and structure of vegetation in field edges was conducted in the summer 1997. Vegetative structure was measured using a modified vegetation profile board (Nudds 1977). A 2 m × 8 cm pole was placed upright in the vegetation and the observer stood 2.5 m away on a line perpendicular to the field's edge. The observer estimated the percentage of the pole obscured at 0–0.25 m, 0.25–0.5 m, 0.5–1.0 m, 1.0–1.5 m, and 1.5–2 m. An index of vertical structure was derived by averaging these 5 values.

Vegetative composition was measured using a modified Daubenmire grid (Daubenmire 1959). A 0.5 × 0.5 m grid was held 1 m above the ground and the absolute cover of vegetation within the grid was visually estimated. Percent cover of bare ground, leaf litter, grasses (including rushes and sedges), forbs (all broad-leafed, non-woody vegetation), and woody vegetation were estimated. Each category was measured independently; thus, the totals could sum to more than 100% when vegetation was multi-layered.

Bird surveys.—Bird densities were measured using line transect and strip transect methods (Lancia et al. 1994). Because the probabilities of detecting a bird on an open field and in the brushy cover of field edges were unequal, field interiors and field edges were surveyed separately.

Fields were classified by crop residue type and selected randomly each year. Field edges were selected randomly within fields. Only one transect was conducted per field in a given year. Subsequent transects were located at least 150 m apart to ensure independence. Surveys were conducted in February each year between sunrise and 11:00 EST on mornings with no precipitation and wind less than 25 kmph. We surveyed both field border and control farms on the same days and alternated which treatment was surveyed first.

Field edges were surveyed with a strip transect method. Each strip was 10 m wide, corresponding to the maximum width of the field borders. On control farms, a corresponding 10 m of crop residue and mowed vegetation was surveyed. The observer walked along the field edge and counted all birds within the 10 m strip. When flushed, sparrows tended to fly along the field edge and land in the vegetation farther down the border. The location of these birds was noted and a bird subsequently flushed was not counted a second time.

Because it was possible for birds to escape detection within field borders, the probability of detecting a bird was estimated by having a field assistant walk through the middle of the field border immediately after the observer finished the transect and flush all remaining birds in the strip by shouting and beating the vegetation. This was repeated for 31 transects. A detection probability was calculated by dividing the number of birds counted by the observer by the total number of birds detected (Lancia et al. 1994). We assumed that the field assistant flushed all birds remaining in the strip. Any violation of this assumption would yield a lower density estimate in field borders. The probability of detecting a bird in a mowed edge was assumed to be 1 because of the lack of vegetation in mowed edges. For the few mowed edges that contained a substantial amount of cover, a field assistant was used in the manner described above to ensure that all birds were counted.

Sparrows were not identified to species during surveys because of the difficulty of observing subtle field marks while maintaining an accurate count of the number present. Relative species composition of sparrows in field edges was estimated by identifying birds while walking between a random subset of transect starting points. Approximately 4.5 h was spent identifying 149 birds in field borders and approximately 1.5 h was spent identifying 22 birds in mowed edges. To avoid the bias of overcounting species that are readily identified from a distance [e.g., Dark-eyed Junco (*Junco hyemalis*)], only observations of perched or standing sparrows made through binoculars were included.

Field interiors were surveyed by walking transects through the middle of fields (45–50 m from field edges in Hyde County and 35–55 m from field edges in Wilson County). The perpendicular distance from the transect line to each individual or cluster of birds was estimated.

Transect lengths were measured with a range finder or by pacing. To avoid observer bias in estimates of distance and flock size, a single observer conducted all surveys.

We conducted 72 strip transects averaging 0.30 ± 0.02 km on field borders and 66 strip transects averaging 0.27 ± 0.02 km on mowed edges ($\bar{x}$ = 0.22 km in Wilson County and 0.38 km in Hyde County). We conducted 62 line transects averaging 0.28 ± 0.03 km on field interiors with field borders and 62 transects averaging 0.26 ± 0.02 km on fields with mowed edges ($\bar{x}$ = 0.19 km in Wilson County and 0.43 km in Hyde County).

Data analysis.—Counts of sparrows in field edges were adjusted for detectability by dividing by the detection probability. These adjusted counts were converted to densities by dividing the adjusted count by the area surveyed for each transect.

In field interiors, sparrows could easily hide in the crop residue and the probability of detecting a sparrow decreased as a function of distance from the survey line. To obtain density estimates, field interior observations were treated as line transect surveys and densities were estimated by fitting a detection function to the data (Buckland et al. 1993) in program DISTANCE (Laake et al. 1993). If sparrows were not randomly distributed on fields and preferred to forage near field edges (Pulliam and Mills 1977, Lima 1990, Lima and Valone 1991, Watts 1991), then densities in field interiors may have been underestimated because sparrow detectability was lowest toward the field edge. It was necessary to pool all transects within treatments to obtain sufficient sample sizes for the program DISTANCE, which diminished our power to discriminate differences between treatments and test for year effects. To compare treatments (i.e., field borders or mowed edges) for field interior surveys, we created an index of abundance by summing all sparrows detected within 50 m of the transect line and dividing the count by the area surveyed for each transect.

Sparrow abundance data for both field edges and interiors were averaged within year, site, and treatment. This design yielded 16 estimates of mean sparrow abundance on field edges and interiors for each farm. Average sparrow abundances were log-transformed because variances were correlated to means. Multivariate homogeneity of variances was tested using a Sen-Puri's test (χ^2 = 28.4, 21 df, $P > 0.05$; StatSoft 1995). Bartlett χ^2 univariate tests of homogeneity of variances for log-transformed mean sparrow densities along field edges (χ^2 = 4.5, 7 df, $P > 0.05$) and sparrow abundance in field interiors (χ^2 = 8.5, 7 df, $P > 0.05$) were not significant (StatSoft 1995). Differences in sparrow abundance on farms with and without field borders were determined from a 3-way MANOVA (StatSoft 1995) with year, treatment, and site as factors. Dependent variables were transformed average sparrow densities for field edges and sparrow abundance for field interiors. Post-hoc comparisons were conducted using Tukey's HSD (StatSoft 1995). Relative proportions of sparrow species were compared using log-linear analysis and Freeman-Tukey deviates (StatSoft 1995). Analyses were conducted using StatSoft version 5.1 for the PC.

RESULTS

Most (93%) birds detected in field edges were sparrows. The remaining 7% consisted primarily of Northern Cardinals (*Cardinalis cardinalis*), American Robins (*Turdus migratorius*), and Yellow-rumped Warblers (*Dendroica coronata*). Of 127 sparrows positively identified in Wilson County, 50% were Dark-eyed Juncos, 24% were Song Sparrows, 15% were White-throated Sparrows (*Zonotrichia albicollis*), 6% were Savannah Sparrows, 3% were Field Sparrows, and 1% were Chipping Sparrows (*Spizella passerina*). Of 44 sparrows positively identified in Hyde County, 50% were Song Sparrows, 36% were Savannah Sparrows, and 14% were Swamp Sparrows (*Melospiza georgiana*). Sparrow species were not distributed randomly with respect to treatment (χ^2 = 52.44, 6 df, P = 0.001). Seven species of sparrows were identified in field borders and four species were found in mowed edges. The species detected only in field borders and not in mowed edges were Field, Chipping, and White-throated sparrows. We observed a greater proportion of the Dark-

TABLE 1. MANOVA results for effects of treatment, year, and site on sparrow abundance.

Source[a]	Wilke's λ	Rao's R	Num df	Den df	*P*
Year	0.41	5.04	2	7	0.044
Site	0.63	2.05	2	7	>0.05
Treatment	0.22	12.17	2	7	0.005
Year × Site	0.63	2.05	2	7	>0.05
Year × Treatment	0.36	6.11	2	7	0.029
Site × Treatment	0.77	1.06	2	7	>0.05
Year × Site × Treatment	0.61	2.23	2	7	>0.05

[a]Year = 1997 vs 1998, Site = Wilson vs Hyde County, Treatment = field borders vs mowed edges.

eyed Juncos in field borders and a greater proportion of Savannah Sparrows in mowed edges.

The probability of detecting a sparrow in a field border was 0.71 ± 0.081. Sparrow abundance was greater on farms with field borders than with mowed edges during our sampling period (Table 1). However, the significant interaction between year and treatment indicates considerable variation in sparrow abundance on farms with mowed edges between years. Sparrow abundance was greater on farms with mowed edges in 1998 than 1997. In field edges, differences in sparrow densities by treatment were noticeably more pronounced in 1997 than 1998. Contrasts indicated that the significant treatment effects from the MANOVA were due to higher sparrow densities in field edges (F = 19.29, 1 df, P = 0.002), but not field interiors (F = 0.14, 1 df, P > 0.05). Sparrow abundance did not differ between sites (Table 1).

In 1997 we detected 33.47 ± 9.5 sparrows/ha in field borders and 5.76 ± 1.7 sparrows/ha in mowed edges. In 1998 we detected 35.69 ± 7.9 sparrows/ha in field borders and 20.90 ± 7.7 sparrows/ha in mowed edges. For both years combined we detected 34.52 ± 6.2 sparrows/ha in field borders and 12.87 ± 3.8 sparrows/ha in mowed edges. In field interiors we detected 8.90 ± 2.7 sparrows/ha in fields surrounded by field borders and 3.93 ± 1.7 sparrows/ha in fields surrounded by mowed edges for both years combined. In field interiors, mean cluster size of sparrows in Wilson Coun-

TABLE 2. Means (SE) of vegetative structure measurements of field edges, with and without field borders, in Hyde and Wilson counties, North Carolina.

	Wilson Co.		Hyde Co.	
Measurement	Field border	Mowed edge	Field border	Mowed edge
Feb. 1997 & 1998				
% Cover[a]	92.3 (2.1)	15.2 (3.4)	74.5 (2.8)	4.1 (1.5)
Median ht. in m[b]	1.12 (.04)	0.48 (0.08)	0.90 (0.05)	0.18 (0.05)
Summer 1997				
Vertical structure[c]	38.9 (2.6)	20.7 (2.4)	22.9 (3.6)	4.6 (3.5)
Bare ground[d]	5.8 (4.2)	21.7 (3.9)	5.0 (5.8)	70.4 (5.6)
Grasses[e]	50.6 (4.9)	49.6 (4.6)	20.5 (6.8)	19.0 (6.5)
Forbs[f]	50.4 (4.3)	39.5 (3.9)	39.5 (5.9)	9.9 (5.6)
Woody[g]	19.0 (2.6)	6.5 (2.4)	5.9 (3.6)	0
Food plants[h]	3.6 (0.5)	2.6 (0.5)	2.3 (0.7)	0

[a] Visual estimate of the percentage of the 10 m strip of field edge that contained standing vegetation over 15 cm.
[b] Visual estimate of median height of standing vegetation.
[c] An index of structure, derived from averaging 5 measurements on density pole.
[d] % cover of bare ground accessible to a sparrow.
[e] % cover of grasses, includes grasses, sedges, and rushes.
[f] % cover of all broad leafed, non-woody vegetation.
[g] % cover of all woody plants.
[h] Index of potential winter food plants, derived from Judd 1901, Martin et al. 1951, Pulliam and Enders 1971, and pers. obs. Index is average of percent coverages for panicum (*Panicum* sp.), ragweed (*Ambrosia artemisiaefolia*), lambsquarter (*Chenopodium album*), dock (*Rumex* sp.), lespedeza (*Lespedeza* sp.), and blackberry (*Rubus argutus*).

TABLE 3. Comparison of wintering sparrow densities on agricultural lands. Note that different methods were used to derive density estimates, and surveys were conducted in different months.

Density (sparrows/ha)	Species	Habitat	Location	Reference
0.0–1.5	Am. Tree Sparrow (*Spizella arborea*)	CRP fields	Nebraska	King and Savidge (1995)
0.1–12.2	Savannah Sparrow	Grasslands	Oklahoma and Texas	Grzybowski (1983)
0.4	Am. Tree and Song sparrows and Dark-eyed Junco	CRP fields	Missouri	Best et al. (1998)
1.1	Am. Tree and Song sparrows and Dark-eyed Junco	Rowcrop fields	Missouri	Best et al. (1998)
3.9	Mostly Savannah Sparrow and Dark-eyed Junco	Rowcrop fields w/out field borders	North Carolina	This study
4.6	Mostly Am. Tree Sparrow	Hedgerows	New York	Petrides (1942)
8.9	Mostly Savannah Sparrow and Dark-eyed Junco	Rowcrop fields w/field borders	North Carolina	This study
12.9	Mostly Savannah and Song sparrows	Mowed field edges	North Carolina	This study
13.4	Savannah and Song sparrows	Mowed, abandoned fields	Georgia	Watts (1990)
14.7	Savannah and Song sparrows	Unmowed, abandoned fields	Georgia	Watts (1990)
26.6	Savannah and Song sparrows	Open[1] old fields next to plowed fields	Georgia	Watts (1996)
34.5	7 sparrow species[2]	Field borders	North Carolina	This study
110.8	5 sparrow species[3]	Open[1] old fields adjacent to brambles	Georgia	Watts (1996)
115.8	Savannah and Song sparrows	Weedy[4] old fields next to plowed fields	Georgia	Watts (1996)
189.1	5 sparrow species[3]	Weedy[4] old fields adjacent to brambles	Georgia	Watts (1996)

[1] Open old fields were 2–6 year old fallow fields with low forb density.
[2] Savannah, Song, Swamp, White-throated, Field, Chipping sparrows and Dark-eyed Juncos.
[3] Savannah, Song, Swamp, White-throated, and Field sparrows.
[4] Weedy old fields were 2–6 year old fallow fields with high forb density.

ty (5.50 ± 1.24 sparrows/cluster) was larger ($Z = 3.22$, $n = 203$, $P < 0.002$) than in Hyde County (1.49 ± 0.12 sparrows/cluster). The cluster size of sparrows we observed in field interiors with mowed edges (4.22 ± 0.38 sparrows/cluster) was larger ($Z = 1.98$, $n = 203$, $P = 0.048$) than in field interiors with field borders (2.06 ± 1.02 sparrows/cluster).

In both winters, field borders had more and taller vegetative cover than mowed edges (Table 2). Vegetative cover and height in field borders and mowed edges were similar between years on all farms, except for Hyde County, where field borders had 85% mean cover in 1997 and 61% in 1998. In the summer of 1997, vegetation in field borders was taller and had more vertical structure and potential food plants than existed in mowed edges. Wilson County field edges contained more vegetative cover than Hyde County field edges (Table 2).

DISCUSSION

Several mechanisms may be responsible for the greater densities of sparrows found on farms with field borders. Field borders might provide better escape cover than mowed edges. Several researchers suggested that sparrows prefer to forage near cover to reduce the risk of avian predation (Schneider 1984, Lima

1990, Watts 1990). Lima (1990) found that White-crowned Sparrows (*Zonotrichia leucophrys*) foraged only near cover even when food was abundant farther from cover. He surmised that this was due to predation risk. We often observed sparrows flying to field borders, wood piles, or adjacent timber stands when disturbed in fields. Because the value of escape cover may be limited by distance (Watts 1991), the presence of field borders in the middle of large farmed openings may make more of the farm landscape available to sparrows (Petrides 1942), particularly for shrub dependent species (Lima and Valone 1991). Field border vegetation also may increase food resources for sparrows, as indicated by the greater amounts of potential winter food plants found in field borders (Table 2). Additionally, field borders may provide thermal protection for sparrows (Grubb and Greenwald 1982).

Wintering sparrow densities vary widely in agricultural landscapes (Petrides 1942, Grzybowski 1983, Watts 1990, King and Savidge 1995, Watts 1996, Best et al. 1998). The sparrow densities we recorded for fields and mowed edges were similar to, and densities in field borders greater than, densities reported in most studies. This suggests that agricultural fields with field borders may provide good wintering habitat for sparrows (Table 3). However, caution should be exercised when comparing densities between studies, because different methodologies were used and species composition differed.

We expected sparrow densities to differ between Wilson and Hyde counties because field border vegetation was taller and denser in Wilson County. Moreover, Wilson County fields were closer to other suitable habitats, such as timber, abandoned house sites, and other uncultivated areas. We had anticipated that juxtaposition of these habitat features would allow more sparrows to take advantage of fields and field borders but this was not observed.

The larger mean cluster size in field interiors with mowed edges may have been a response to increased perceived predation risk (Barnard 1980). Sparrows also may have been concentrated because less suitable foraging habitat was available on fields with mowed edges. The smaller mean sparrow cluster size we observed in Hyde County field interiors may be due to the higher proportion of Savannah Sparrows, which tended to be solitary or form looser flocks than other sparrows.

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